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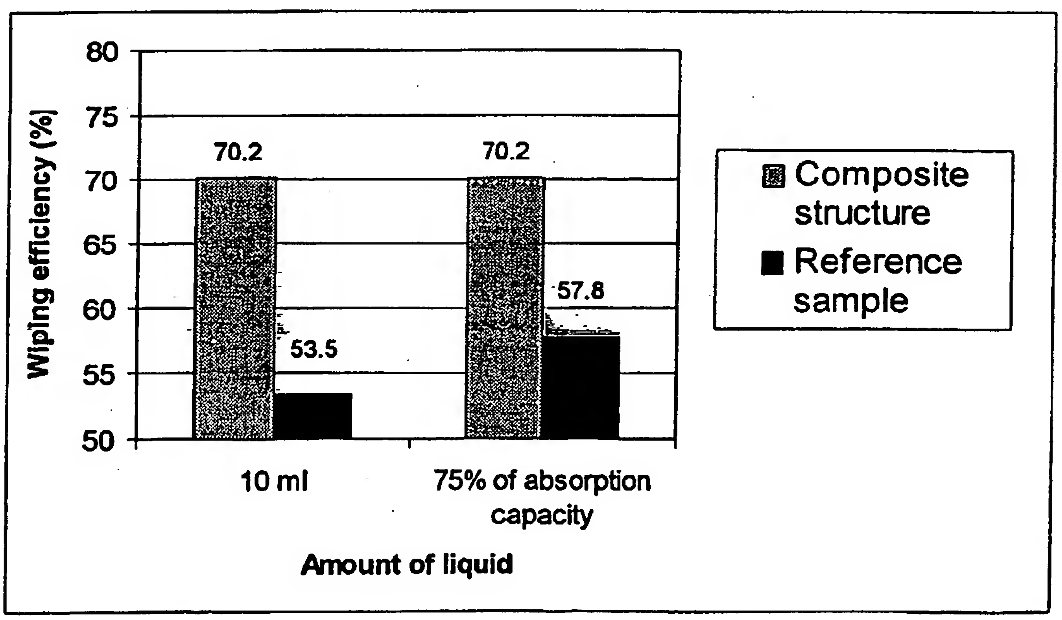

(57) **Abstract:** The invention concerns a composite nonwoven formed from fibrous layers bonded together by entanglement of fibers of the layers, wherein the fibrous layers comprise first and second outer layers each comprising a mixture of hydrophobic and hydrophilic fibers, as well as an intermediate layer of hydrophobic fibers sandwiched between the first and the second outer layers, the weight ratio between the hydrophobic and hydrophilic fibers in the first and the second layers being 20:80 to 80:20. The invention also concerns the manufacture of the nonwoven, as well as its use, especially as a wet wipe.

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COMPOSITE NONWOVEN, ITS USE AND METHOD OF MANUFACTURE

Field of the invention

The present invention relates to composite nonwovens, to their use and to a method of manufacture of the composite nonwovens. More particularly, it discloses a new entangled composite nonwoven material comprising at least three layers. The nonwoven material according to the invention can be used as a substrate for wiping articles, especially for use as a substrate for wet wipes, where good liquid absorption and release properties are needed.

Background of the invention

In hydroentanglement of a fiber web, fine, high-speed water jets bond the fiber web in a similar way to the needles in a needlepunching process. These high-pressure water jets cause a rearrangement of the fibers in all three directions of the structure and as a consequence thereof significant bonding without the use of added binders or additional bonding (e.g. thermal) can be achieved. In a widely applied process, a carded web is placed on a moving conveyor belt, which transports the web under several rows of water jets. The water pressure in the jets is increased stepwise from the first array of jets to the last array. More information about hydroentanglement can be found, for example, in the patents US 3,485,706 and US 3,485,708 (Evans), which patents are incorporated herein by reference.

Various types of fiber compositions can be used to produce hydroentangled nonwovens. Typical fibers used are cellulose-based fibers such as cotton, pulp or viscose, as well as synthetic fibers such as polyester (typically polyethylene terephtalate). A widely used fiber mixture ratio is 30-70% viscose fibers and 70%-30% polyester fibers by weight of the web.

Hydroentangled nonwovens have been used as substrates for pre-moistened wipes, i.e. so-called wet wipes. In the course of a wiping action, the liquid in the pre-moistened wipe is to be released onto the surface that is wiped, for example for cleaning or polishing the surface. In some applications the liquid that is released should provide some special function on the surface, such as moisturising of skin or disinfecting the surface.

The substrate used for wet wipes, such as a hydroentangled nonwoven, should possess both desirable liquid absorption and retention characteristics, as well as sufficient liquid release properties.

While nonwoven substrates comprising viscose and polyester fibers provide good liquid absorption and retention characteristics, these substrates release typically less than 50% of the moisturising liquid during a wiping action. This means that only a small amount of the added liquid contributes to the intended function, such as cleaning, polishing or disinfecting function. Thus, there exists a need to improve the liquid release properties of nonwoven substrates used to manufacture especially wet wipes.

It has been observed that the more hydrophobic fibers, such as polypropylene (PP) fibers there are in a nonwoven material, the better are the liquid release properties. Hydrophobic fibers are characterized by having a water contact angle greater than 90°. Due to the hydrophobic fibers, the capillary pressure of water-based liquids is low or even negative in the nonwoven material. Consequently, water-based liquids can be easily released from the nonwoven during a wiping action and the amount of residual liquid in the wiping article after the wiping is minimized.

The water absorption properties of a nonwoven containing PP fibers are significantly poorer than the absorption properties of nonwovens containing more hydrophilic fibers. When the amount of hydrophobic polypropylene fibers is increased in the nonwoven, the spontaneous absorption of water-based liquids decreases. This can be observed e.g. as an increasing run-off of liquid on the nonwoven surface, when the material is being wetted.

The use of hydrophobic polypropylene fibers in nonwovens to be used as substrates for wiping articles is limited as the liquid absorption properties decrease when the amount of polypropylene fibers increases. Due to the chemical nature of polypropylene, fibers made of polypropylene have a low-energy surface with a water contact angle of about 105°. The hydrophobic nature of a nonwoven material containing PP fibers thus results in non-optimal cleaning properties of the nonwoven used as a wiping article. The liquid absorption capacity and absorption rate of the nonwoven are low, resulting also in a relatively poor drying ability of the nonwoven during a wiping action.

Composite and layered nonwoven fabrics are known from the prior art. By a layered composite structure is meant a nonwoven fabric, which has at least two layers containing at least partly different fibers or fiber compositions. Typically the different nonwoven layers are first manufactured separately and then combined e.g. by calander bonding. The patent application WO 98/03713 discloses a multiple layer nonwoven basesheet to be used as a substrate for a wet wipe, wherein the various layers can contain different types of fibers. The properties of the obtained products can be altered by e.g. choosing suitable fiber combinations and treatments. In order to e.g. bond fibers together, one or more of the separate layers can be treated thermally before bringing together with the other layers. The Japanese patent application JP2001336053 discloses a nonwoven consisting of a hydrophobic, thermally bonded middle layer and outer layers containing hydrophilic fibers.

The composite nonwoven fabrics can also be formed on-line, i.e. the various layers (e.g. carded webs) are formed and brought together one on top of the other, whereafter the layers are bonded together. For this purpose different bonding methods can be used. The EP 0 531 096 discloses the use of a large number (ten) of carding devices, which are fed with different fiber compositions or different fibers and the webs are typically entangled by hydraulic entangling.

Summary of the invention

The present invention concerns a composite nonwoven formed from fibrous layers bonded together by entanglement of fibers of the layers, wherein the fibrous layers comprise first and second outer layers each comprising a mixture of hydrophobic and hydrophilic fibers, as well as an intermediate layer of hydrophobic fibers sandwiched between the first and the second outer layers, the weight ratio between the hydrophobic and hydrophilic fibers in the first and the second layers being 20:80 to 80:20.

According to the invention, the fibrous webs that are used to form the layers of the composite consist of non-bonded fibers, i.e. are free of fibers which e.g. have been thermally bonded or bonded with e.g. a binder or an adhesive, i.e. they are binder-free. The webs combined to form the layered composite are mutually bonded or interlocked solely by hydroentangling the fibers. However, the hydroentangled and dried composite product may, if desired, be further

treated, for example by patterning or embossing to form a patterned or embossed composite nonwoven.

The composite nonwoven according to the invention is intended to be used as a substrate for wiping articles, especially wet wipes. The said composite nonwoven material has improved liquid absorption properties, as well as improved liquid release properties.

An object of the invention is also a method of manufacturing a composite nonwoven comprising the steps of

forming a layered web comprising first and second outer layers each comprising a mixture of hydrophobic and hydrophilic fibers and an intermediate layer of hydrophobic fibers sandwiched between the first and the second outer layers, whereby the ratio of hydrophobic to hydrophilic fibers is 20:80 to 80:20 in the first and second outer layers,

hydroentangling the layered web to bond the layers by entanglement of fibers,

drying the hydroentangled web.

Brief description of the drawings

In the drawing,

Figure 1 shows a hydroentanglement production line with three carding stations,

Figure 2 shows the cumulative volume of filled pores, measured during receding run,

Figure 3 shows liquid absorption curves of the samples,

Figure 4 shows the cumulative liquid release of wet samples measured with a wiping device,

Figure 5 shows the wiping efficiency of dry samples measured with a wiping device,

Figure 6 shows the pore volume distribution, and

Figure 7 shows the cumulative volume of filled pores, measured during advancing run.

Detailed description of the invention

The structure of the nonwoven according to the invention thus comprises a first and a second outer layer, as well as a third layer, the outer surfaces of which each faces an outer surface of the first and second outer layer, respectively, forming a sandwich structure, with the third layer being sandwiched between the first and second layer. The absorption and release properties of such a structure are favourable for the purpose of wet wipe applications. The

present invention provides a nonwoven composite material that surprisingly has good release properties for water based liquids. Also the absorption properties and bulkiness of the material are good. Preferably the fibers are staple fibers from which a carded fibrous web can be formed.

Typical hydrophobic fibers for use in the nonwoven, in the outer layers and/or to form the fibers in the intermediate layer, are for example polyolefin fibers such as polypropylene and/or polyethylene fibers. Preferably polypropylene fibers are used. Polypropylene fibers have many advantages, such as low density as well as low shear and elastic moduli. In hydroentangled nonwovens, these properties of polypropylene fibers result in soft and bulky nonwoven materials. Suitable hydrophobic fibers for producing hydroentangled nonwovens are fibers having a titer of 1.3-3.8 dtex. According to a preferred embodiment of the invention, the hydrophobic fibers in the first and second outer layers are the same hydrophobic fiber as in the intermediate layer. It should be noted that also fibers made from a hydrophilic synthetic or natural polymer can be used as hydrophobic fibers, if a water contact angle of greater than 90° is achieved by a suitable surface treatment. These surface treatments can be for example chemical surface treatments with a wax, fluorocarbon or silicone. The hydrophobic fibers can also be multicomponent fibers including a hydrophilic or a hydrophobic core polymer and a hydrophobic surface.

According to an embodiment of the invention, the hydrophilic absorbing fibers are selected from the group of cellulose based fibers, such as viscose, cotton or pulp fibers. Preferably, viscose or lyocell are used as the hydrophilic fibers. Hydrophilic fibers are here defined as fibers having an average water contact angle of less than 90°.

According to a further embodiment of the invention, the weight ratio between the hydrophobic and hydrophilic fibers in the first and second outer layers is 30:70 to 70:30. According to a further embodiment, the first and second outer layers are the same, that is, they are made from the same fiber mixture. According to a further preferred embodiment, the first and the second outer layers consist of polyolefin, such as polypropylene, and viscose fibers. Advantageously the intermediate layer consists of polyolefin, such as polypropylene fibers. According to a further embodiment, the first and second outer layers consist of polypropylene and viscose fibers in a weight ratio of appr. 50:50, the intermediate layer consisting of polypropylene fibers. According to a further preferred embodiment, the nonwoven material

consists of three layers, that is of a first and second outer layer, as well as a third layer, the outer surfaces of which each faces an outer surface of the first and second outer layer, respectively, forming a sandwich structure.

In a typical nonwoven according to the invention, the weight of each layer can be 10 – 80 g/m^2. The weight of the intermediate layer can often be greater than the weight of each outer layer.

The nonwoven composite material according to the invention is made by a hydroentanglement process that involves the general steps of forming a layered web of fibers, hydroentangling the web, drying the web and winding the hydroentangled nonwoven material. According to the invention the layered web can be formed by providing a first and a second web each comprising a mixture of hydrophobic and hydrophilic fibers, providing a third web of hydrophobic fibers, conveying the so formed webs as such to join the webs in a facing relationship with each other so as to sandwich the third web between the first and the second webs.

A hydroentanglement production line for making a three-layered web is schematically shown in Figure 1, where the parts are as follows: (11A, 11B, 11C) are fiber feeders for the webs A, B and C, respectively. The fibers can be staple fibers crimped and cut from polymer filaments. The reference numbers (12A, 12B, 12C) denote carding stations for the same webs, and (13) denotes the 1st hydroentanglement station, (14) the 2nd hydroentanglement station, (15) is the dryer and (16) a nonwoven winder.

After carding in the carding stations (12A, 12B, 12C), the separate webs A, B and C, consisting of carded fibers, are conveyed as such to the 1st hydroentanglement station (13) without additional intermediate treatments, i.e. mechanical (e.g. compacting), chemical and/or thermal treatments. As a result, after carding, the properties of the fibers and the webs are substantially maintained until the 1st hydroentanglement station (13).

Each of the separate webs A, B and C are brought together in contact prior to the first hydroentanglement station, the web B being sandwiched between webs A and C, where the layers are bonded by entanglement, leading to a bonded product where some of the fibers from one layer may extend into the adjacent layer to secure the layers together. This

mechanical interlocking of the layers leads to a composite structure with a hydrophobic intermediate zone which increases in hydrophilicity in a direction towards the outer zones and surfaces of the composite structure, which structure gives the product its beneficial properties.

Liquid is mostly absorbed and retained in nonwoven materials in the capillaries which are formed between the fibers in the nonwovens. The ability of a porous material, such as a nonwoven, to absorb and retain liquid can be characterized by the capillary pressure of liquid in the pores of the material. The capillary pressure is defined by the Laplace equation that is well known in the art:

$$P = (2\,\gamma \cos\theta)/\,r$$

where P is the capillary pressure, γ is the surface tension of the wetting liquid, θ is the contact angle between the liquid and the capillary wall, and r is the radius of the capillary. The liquid absorption rate is proportional to the capillary pressure, and the rate increases with increasing capillary pressure. The relation is given by Washburn equation

$$dV/dt = (r^2\,A)dP\,/8\eta L$$

where A is the cross-sectional area and L is length of the capillary, η is the liquid viscosity.

Unexpectedly it was found according to the invention that not only does the amount of hydrophobic fibers in the nonwoven affect the release properties, but also the structure of the nonwoven fabric. This has been verified with tests comparing two nonwoven fabrics with the same polypropylene content but with different structures. The structure according to the invention was a layered structure as defined, whereas that of comparison had a uniform, non-layered structure but the same polypropylene content. Hereby it was observed that the composite structure had remarkably better absorption and release properties.

During a wiping action with a wet wipe, liquid should be released from the wipe on the surface as completely as possible. In this case the pressure that is needed to release liquid from a wet wipe is directly proportional to the capillary pressure of the liquid in the capillaries

of the wipe. Hence, it is desirable to produce a nonwoven substrate that has relatively low capillary pressure towards the wetting liquid.

The capillary pressure can also be decreased by increasing the average pore size of the nonwoven material. One method of increasing the average pore size is to increase the diameter (denier) of the fibers that are used for manufacturing the nonwoven material. Pore size distribution depends also on the process technology and process settings such as hydroentanglement energy used for the production of the nonwoven.

The pore volume distribution of nonwovens can be determined e.g. by liquid porosimetry. In the present invention the pore volume distribution is measured using the technique developed at the Textile Research Institute (TRI) in Princeton, New Jersey, USA. The technique is described more in detail by Miller and Tyomkin in the Journal of Colloid and Interface Science, volume 162 (1994), pages 163-170, which is included herein for reference. The use of this technique is described in more detail in the Examples.

The nonwovens according to the invention can be characterized by their pore volume distribution. Preferably, in the composite structure according to the invention, at least 70% of the total pore volume is associated with pores having an effective radius of greater than 125 μm, or equivalently a capillary pressure smaller than 530 Pa during liquid absorption. They can further be characterized by at least 30% of the total pore volume being associated with pores having an effective radius of greater than 150 μm or equivalently a capillary pressure smaller than 440 Pa during liquid absorption. Preferably the pores have an effective radius of not greater than 800 μm. It should be noted however that these values for pore radius and capillary pressure refer to the values measured during liquid absorption (advancing cycle). Due to contact angle hysteresis between liquid absorption and desorption, smaller pore volumes or higher capillary pressure would be obtained when the pore volume distribution is measured from liquid desorption (receding cycle). It should also be noted that the pore volume distribution of the composite structure represents the average value of all the layers. As stated above the pore volume distribution of the final product is effected by a number of process parameters, including the used raw materials, the fiber dimensions, carding conditions, hydroentanglement conditions, such as pressures used etc the choice of which are known to or can be determined by the person skilled in the art.

Optionally, the products of the invention can also be characterized by the cumulative volume of filled pores, such volume being less than 35%, preferably less than 30% of the total pore volume as measured from liquid desorption at a pressure of 1650 Pa (corresponding to a pore radius of 40 μm). At an increased pressure of 3300 Pa (pore radius 20 μm) the cumulative volume is decreased to less than 10%, preferably less than 8%.

EXAMPLES

Description of the samples

Both the sample according to the invention and the reference sample were made using comparable process settings.

Composite structure

The outermost webs of the composite structure consist of a mixture of 50 % polypropylene and 50 % viscose and the basis weight of these webs is 15 g/m^2. In the middle of the structure, sandwiched between the outermost layers there is a layer of 100 % polypropylene (20 g/m^2). Thus, the polypropylene content of the whole structure is 70 % and the entire grammage is 50 g/m^2. The composite structure was made in an apparatus corresponding to that of Figure 1 by feeding the appropriate fiber mixtures to the different fiber feeding stations. In the hydroentanglement, the different webs are entangled together by water jets during which the layers are mixed to some degree, basically forming an intermediate zone with a high degree of hydrophobicity which gradually becomes more hydrophilic in a direction towards the outer zones of the hydroentangled web. The layers are bonded together and cannot be separated.

Reference sample

The reference sample consists of an essentially uniform mixture of 70 % polypropylene and 30 % viscose. The basis weight is also 50 g/m^2. The reference sample is manufactured with three cards but all the cards are fed with the same fiber composition. The composite and reference samples are used as such in the following tests, without any further treatment.

Test methods

Liquid absorption and release properties and pore volume distribution

Liquid porosimetry technique

Liquid absorption and release properties and the pore volume distribution were studied with the liquid porosimetry technique (TRI Autoporosimeter) developed at the Textile Research Institute (TRI) in Princeton, New Jersey, USA. The technique is described more in detail by Miller and Tyomkin in the Journal of Colloid and Interface Science, volume 162 (1994), pages 163-170. The chamber of the Autoporosimeter was equipped with a nitrocellulose membrane having a nominal pore diameter of 1.2 μm (Millipore type RAWP, Millipore Corporation, Bedford, Massachusetts, USA). The liquid used was a 0.1 wt% water solution of Triton X-100 (surface tension 33 mN/m). A 5.5x5.5 cm^2 specimen was cut from the nonwoven samples and it was covered with a plexiglass plate having the same dimensions and a weight of 23.9 g (corresponding to a pressure of about 80 Pa). The measurements were carried out in the pore radius range of 5-800 μm corresponding to pressure range of 13200-83 Pa. The measurement can comprise both the advancing (liquid absorption) and the receding (liquid desorption) measuring cycles. For the analysis, a blank measurement without the sample was subtracted from the original data. The Figure 6 shows the pore volume distribution during liquid absorption and desorption and Figure 7 shows the cumulative pore volume during absorption for the above mentioned composite and reference sample.

Dynamic wiping tests

The dynamic tests were carried out with a wiping device. There were two different test types, which were used for testing wet and dry wiping properties.

Wiping test (wet sample)

The sample (7 cm x 10 cm) consisting of 4 g test liquid/g nonwoven was affixed to the bottom side of a 2.4 kg sled (corresponds to a load of 4.8 kPa). The liquid used was a 0.1 wt% water solution of Triton X-100 (surface tension 33 mN/m). The sled was pulled a distance of 1 m at a rate of 50 cm/s against wax cloth (3 mm of wad was under the wax cloth) and the amount of liquid released during the pull was measured with a balance. 7 consecutive pulls (= 1 measurement) were done with the same sample.

Wiping test (dry sample)

The sample which dimensions were 10,3 cm x 16,8 cm was affixed to the bottom side of a 1,3 kg (1,0 kPa) sled. The liquid, which in this case was water, was spred evenly to the steel base with a pipette. Two different amounts of liquid were used for each sample: 10 ml, and the volume which was 75 % of the absorption capacity of the sample. The sled was pulled at a rate of 20 cm/s against the base and the amount of liquid absorbed to the sample during the pull was measured with a balance.

<u>Basic tests</u>

Basis weight

The basis weight of the nonwoven was determined according to the Edana Recommended Test Method ERT 40.3-90. The reported values are averages of 10 individual measurements.

Thickness

The thickness of the nonwoven was determined according to the Edana Recommended Test Method ERT 30.5-99. The reported values are averages of 10 individual measurements.

Tensile strength and elongation

The tensile strength and the elongation of the nonwoven materials were determined according to the Edana Recommended Test Method ERT 20.2-89, expect that the extension rate was 300 mm/min. The reported values are averages of 5 individual measurements.

Amount of the components

This test method, which is based on the SFS-ISO 1833 (1991) standard, is applicable to binary mixtures of polypropylene fibers with viscose, polyester, wool, cotton etc.

The required amount of nonwoven was taken and the dimensions of the sample were measured. The weight of the sample was determined by using an analytical balance. The viscose was dissolved from the nonwoven with 60 % sulphuric acid at a temperature of 60 °C. The sample was mixed with a glass rod and the dissolving time was six minutes. After dissolving, the sample was rinsed carefully with deionized water and it was dried for one to two hours at 105 °C in a ventilated oven. The sample was cooled at room temperature for

about one hour and the mass of insoluble component (PP) was expressed as a percentage and gsm of the total mass of fiber in the mixture. The proportion of soluble component (e.g viscose) was calculated from the loss in mass. The number of parallel measurements was four.

The basic test results of the samples are presented in Tables I and II.

Table I.

	Basis weight (g/m^2)	Thickness (mm)	Amount of the components Polypropylene	Viscose
Composite structure				
Avg	49.2	0.72	67.2	32.8
Std	2.0	0.02	1.0	1.0
Min	45.7	0.68	66.1	31.8
Max	52.0	0.75	68.2	33.9
N	20	20	4	4
Reference sample				
Avg	54.2	0.64	69.8	30.2
Std	1.2	0.03	0.4	0.4
Min	51.7	0.58	69.3	29.8
Max	56.8	0.69	70.2	30.7
N	30	30	4	4

Table II.

	Tensile dry (N)		Tensile wet (N)		Elongation dry (%)		Elongation wet (%)	
	MD	CD	MD	CD	MD	CD	MD	CD
Composite structure								
Avg	68.9	24.3	48.7	16.7	57.4	139.2	51.1	112.0
Std	3.3	3.0	8.6	1.4	2.9	10.9	7.3	10.2
Min	64.2	19.0	37.5	14.8	51.6	121.5	41.9	99.4
Max	75.9	28.0	63.3	19.1	61.5	154.3	63.1	132.3
N	10	10	10	10	10	10	10	10
Reference sample								
Avg	85.3	18.0	66.2	10.6	58.8	158.2	57.7	139.1
Std	5.0	2.1	7.3	2.2	5.0	11.0	4.8	9.8
Min	79.6	13.8	52.1	7.4	46.8	140.0	48.4	120.8
Max	95.6	20.7	76.5	14.9	65.4	177.0	64.1	153.1
N	15	15	15	15	15	15	15	15

Example 1

The liquid porosimeter was employed in both advancing and receding modes. During the advancing run, the sample was wetted by the test liquid and the receding part was used to determine the liquid release properties. Cumulative volumes of the filled pores are shown in Figure 2. The pore radius range 5-50 µm corresponds to the pressure range 13200-1320 Pa. Cumulative volumes of filled pores at 10, 20, 30, 40 and 50 µm as a percentage (correspond to the pressures of 6600, 3300, 2200, 1650 and 1320 Pa) are presented in Table III. The selection of this pressure range is based on the estimate of pressures used during the wiping procedure in different wiping applications (baby wet wipe, household etc.). From Figure 2 and Table III it is seen that the amount of filled pores in the composite structure is smaller than in the reference sample. Thus, according to the liquid porosimeter measurements, the release properties of the composite structure are better as compared to the reference sample.

Table III.

Sample #	**Percentage of filled pores at 10 μm**	**Percentage of filled pores at 20 μm**	**Percentage of filled pores at 30 μm**	**Percentage of filled pores at 40 μm**	**Percentage of filled pores at 50 μm**
Composite structure	2.83	6.54	14.10	26.42	43.84
Reference sample	5.96	10.17	20.50	39.22	72.18

Using the same measurement circumstances the maximum absorption capacity of the composite structure was at the end of the measurement better as compared to the reference sample (Fig. 3).

Example 2

Wiping test (wet sample)

The wiping test with wet samples indicated the difference between the composite structure and the reference sample (Figure 4). The liquid release is higher for the composite structure than for the reference sample. For example, after three consecutive releases the composite structure retained about 10% less liquid than the reference sample.

Wiping test (dry sample)

The results from the wiping test with dry samples showed that the wiping efficiency was better for the composite structure (Figure 5). The composite structure is capable of absorbing 12.4 – 16.7% more liquid during the wiping test than the reference sample.

Claims

1. A composite nonwoven formed from fibrous layers bonded together by entanglement of fibers of the layers, characterized in that the fibrous layers comprise first and second outer layers each comprising a mixture of hydrophobic and hydrophilic fibers, as well as an intermediate layer of hydrophobic fibers sandwiched between the first and the second outer layers, the weight ratio between the hydrophobic and hydrophilic fibers in the first and the second layers being 20:80 to 80:20.

2. A nonwoven according to claim 1, characterized in that the hydrophobic fibers are polyolefin fibers, such as polypropylene or polyethylene fibers.

3. A nonwoven according to claim 1 or 2, characterized in that the hydrophilic fibers are selected from the group consisting of cellulose-based fibers, such as viscose, cotton or pulp fibers.

4. A nonwoven according to any one of claims 1 to 3, characterized in that the hydrophobic fibers in the first and second outer layers are the same as in the intermediate layer.

5. A nonwoven according to any one of the claims 1 to 4, characterized in that the fibers are carded staple fibers.

6. A nonwoven according to any one of the preceding claims, characterized in that the nonwoven has an average pore volume distribution wherein at least 70% of the total pore volume is associated with pores having an effective radius of greater than 125 μm.

7. A nonwoven according to any one of the preceding claims, characterized in that the nonwoven has an average pore volume distribution wherein at least 30% of the total pore volume is associated with pores having an effective radius of greater than 150 μm.

8. A nonwoven according to any one of the preceding claims, characterized in that the weight ratio between the hydrophobic and hydrophilic fibers in the first and second outer layers is 30:70 to 70:30.

9. A nonwoven according to any one of the preceding claims, characterized in that in the first and the second outer layers, the hydrophobic fibers are polypropylene fibers and the hydrophilic fibers are viscose fibers, the hydrophobic fibers of the intermediate layer being polypropylene fibers.

10. A nonwoven according to claim 9, characterized in that the first and second outer layer contain polypropylene and viscose fibers in a weight ratio of 50:50.

11. A nonwoven according to any one of the preceding claims, characterized in that the weight of the layers are 10 – 80 g/m^2.

12. A nonwoven according to any one of the preceding claims, characterized in that the fibrous layers consist of a first and second outer layer, and an intermediate layer.

13. A wiping article, especially a wet wipe, comprising a composite nonwoven substrate according to any one of the preceding claims.

14. The wiping article according to claim 13 loaded with a wiping liquid, such as an aqueous solution, emulsion, dispersion or lotion.

15. The wiping article according to claim 14 wherein the amount of liquid in the article is 2-5 g of liquid per g of dry nonwoven substrate.

16. Method of manufacturing a composite nonwoven comprising the steps of

- forming a layered web comprising first and second outer layers each comprising a mixture of hydrophobic and hydrophilic fibers, and an intermediate layer of hydrophobic fibers sandwiched between the first and the second outer layers, whereby the ratio of hydrophobic to hydrophilic fibers is 20:80 to 80:20 in the first and second outer layers,
- hydroentangling the layered web to bond the layers by entanglement of fibers, and
- drying the hydroentangled web.

17. The method according to claim 16, wherein the layered web is formed by providing a first and a second web each comprising a mixture of hydrophobic and hydrophilic fibers, as well as a third web of hydrophobic fibers, conveying the so formed webs to combine the third web in facing relationship with each of the first and the second web, to sandwich the third web between the first and the second webs.

18. The method according to the claim 17 wherein the first, second and third webs are carded webs made from staple fibers.

19. The method according to any one of the claims 16 to 18 comprising the further step of adding a liquid to the formed composite nonwoven, preferably in an amount of 2 to 5 g per g of composite nonwoven.

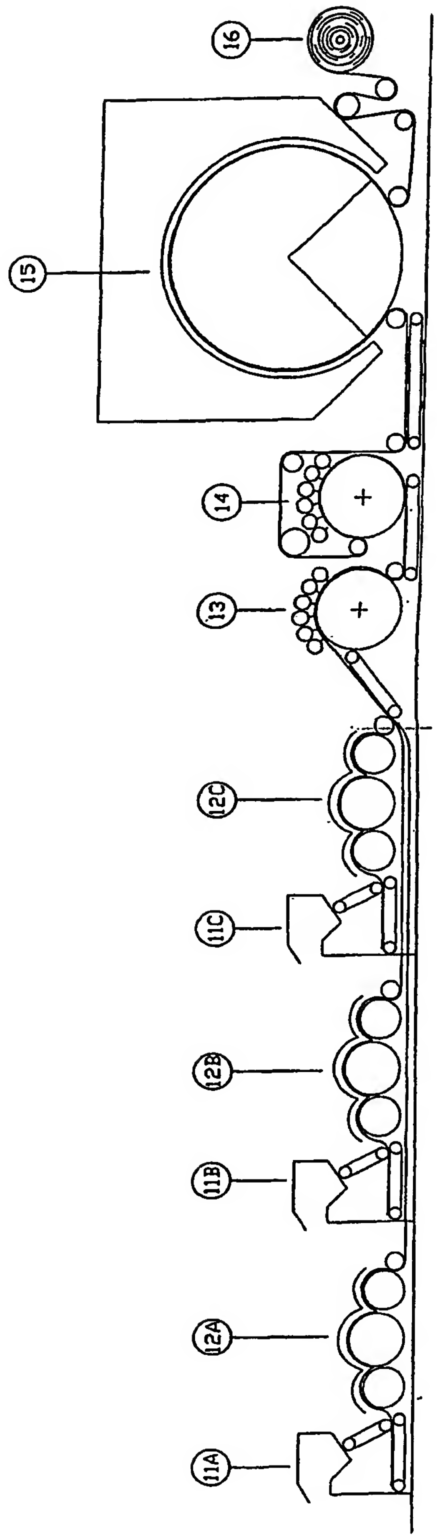

FIG. 1.

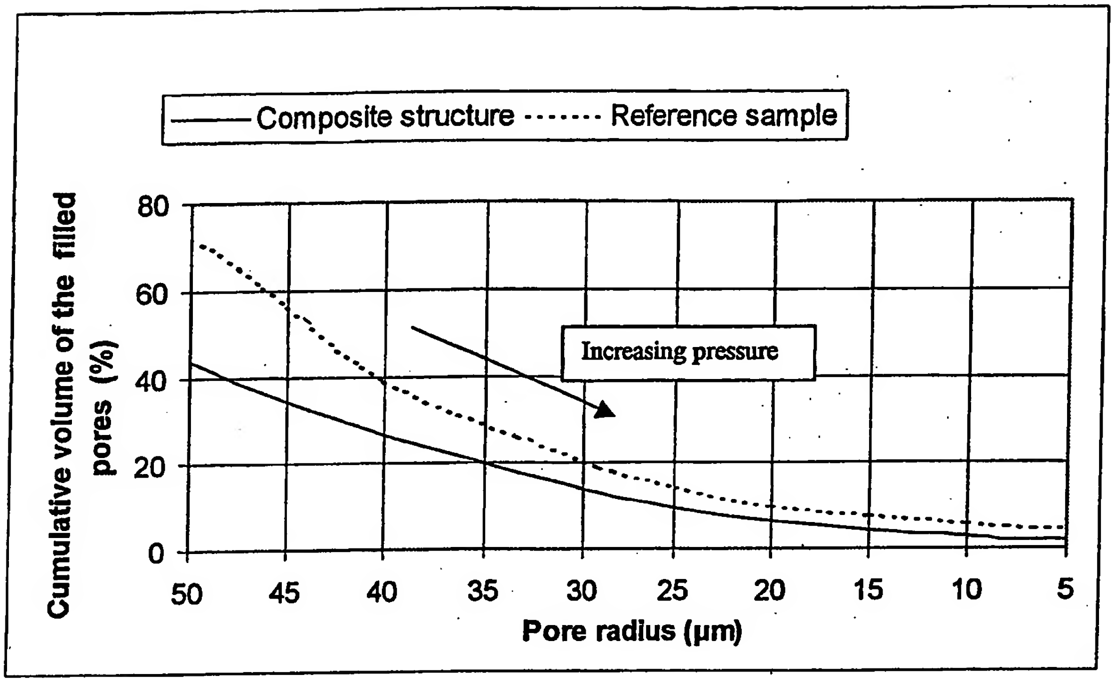

Figure 2.

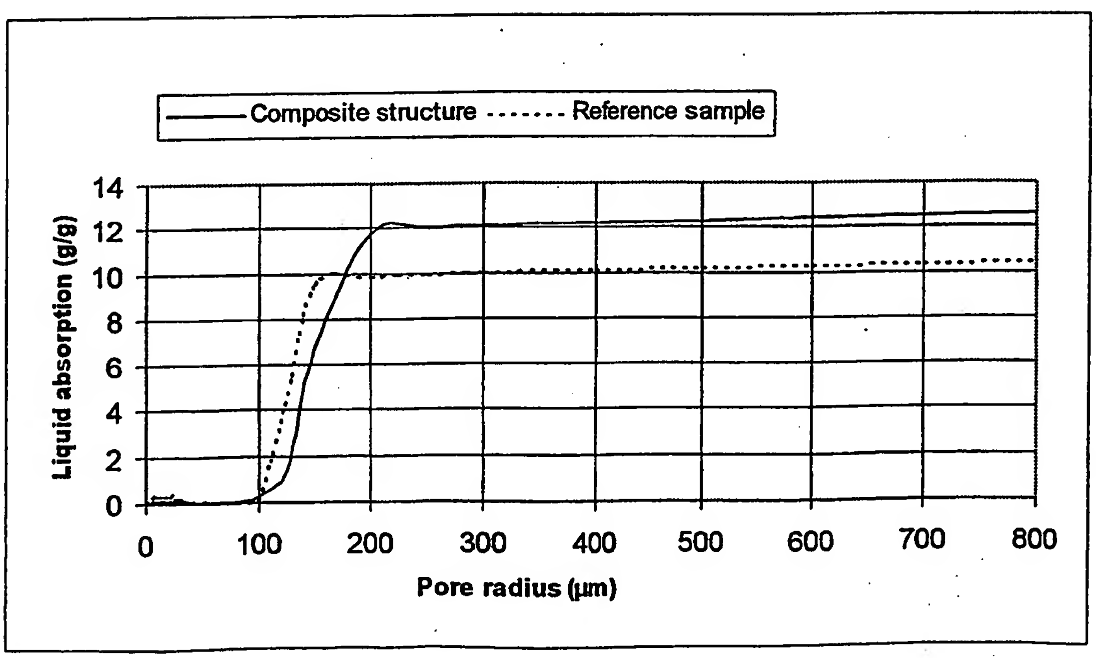

Figure 3.

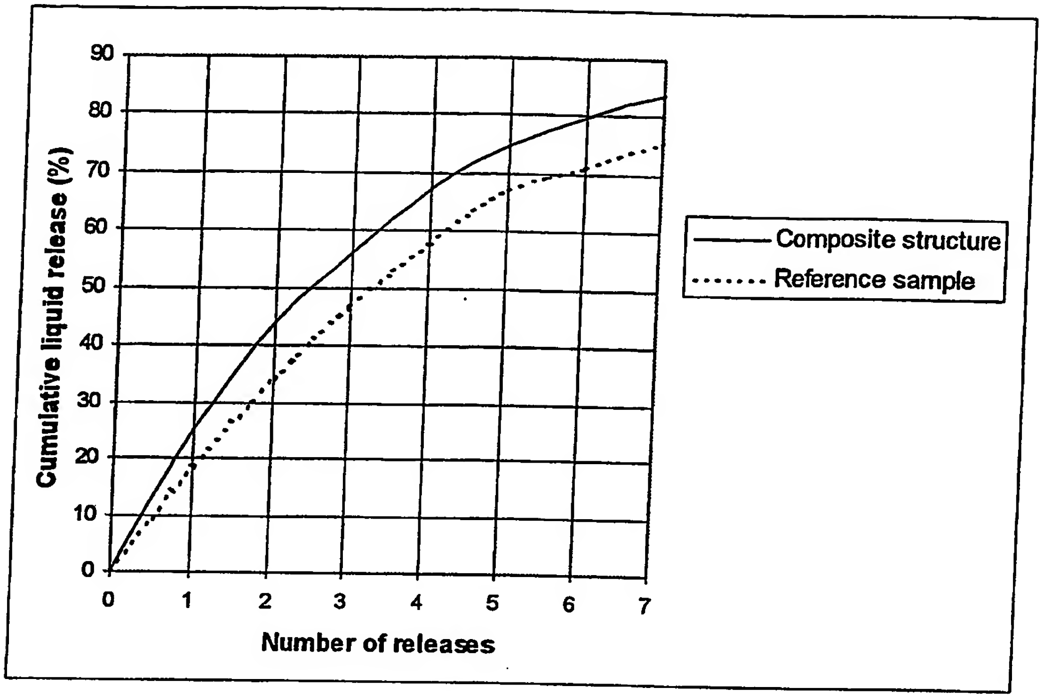

Figure 4.

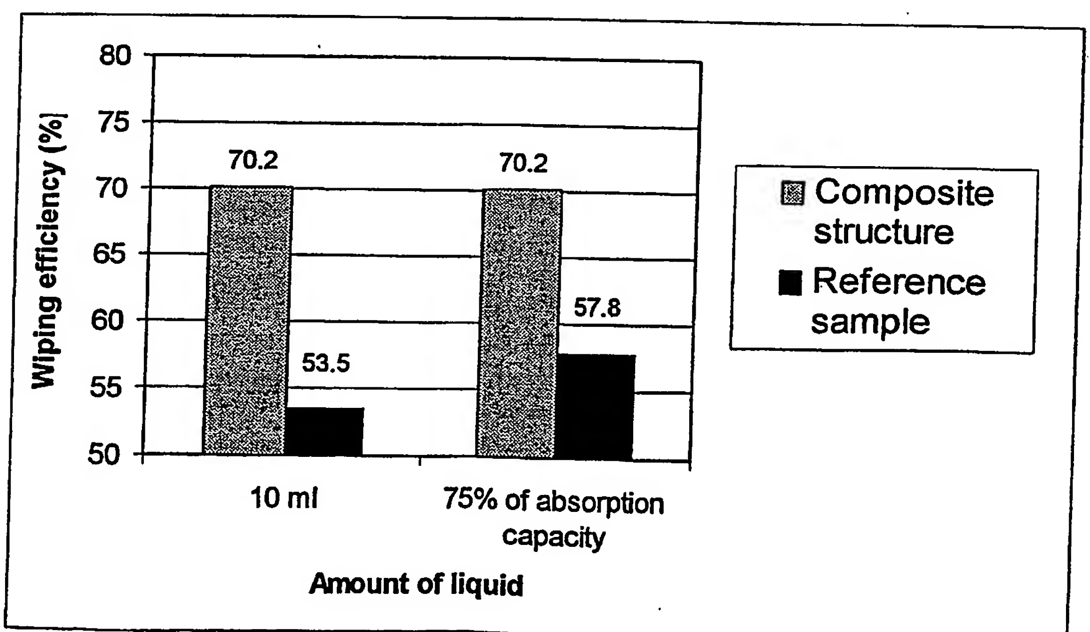

Figure 5.

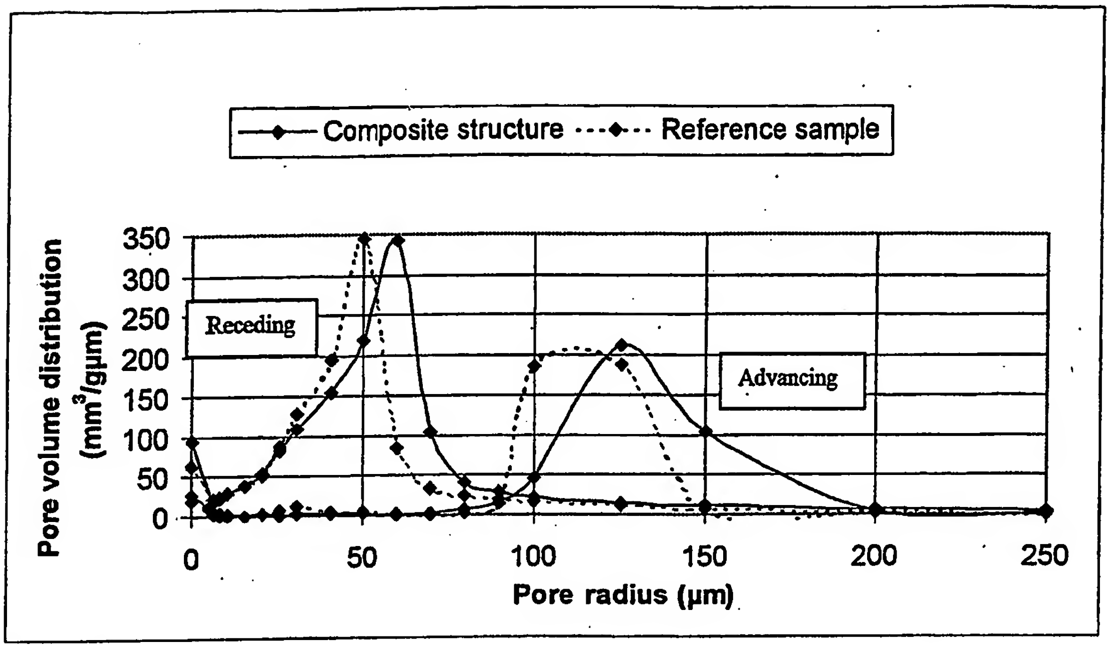

Figure 6.

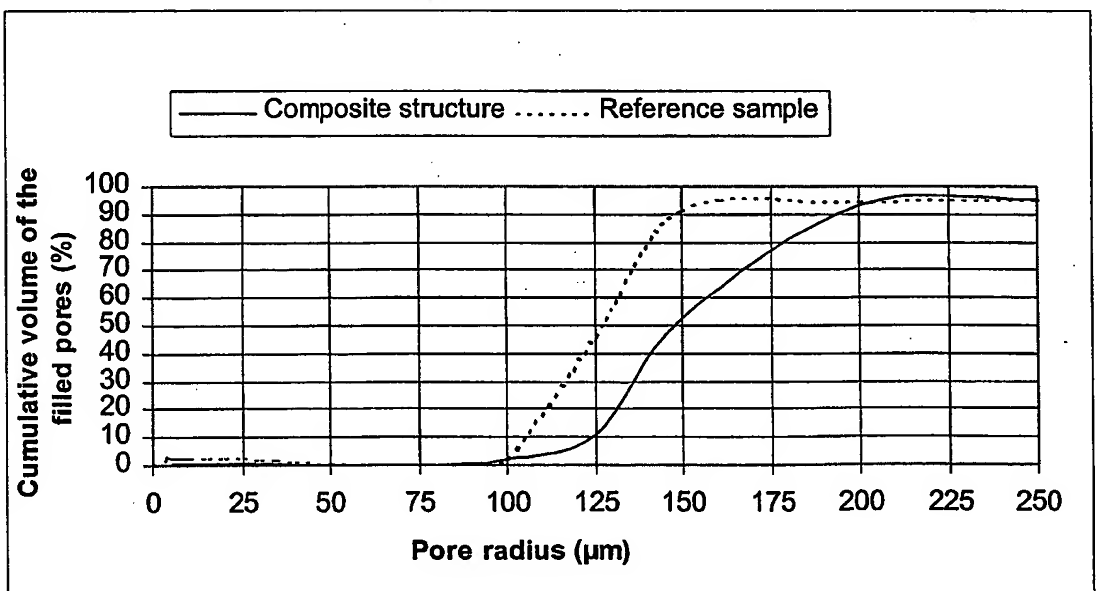

Figure 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 02/00995

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: D06M 17/00, D04H 13/00, A47L 13/17

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: D06M, D04H, B32B, A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0236339 A2 (THE PROCTER & GAMBLE COMPANY), 10 May 2002 (10.05.02), page 4, line 1 - line 20; page 5 - line 9, figures 1a and 16 --	1-19
A	WO 0166345 A1 (THE PROCTER & GAMBLE COMPANY), 13 Sept 2001 (13.09.01), abstract --	1-19
A	US 6028018 A (JOHN DAVID AMUNDSON ET AL), 22 February 2000 (22.02.00), column 2, line 1 - line 49, abstract --	1-19

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
5 March 2003	07 -03- 2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Marie Karlsson/Els Telephone No. +46 8 782 25 00

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Week 200227 Derwent Publications Ltd., London, GB; Class F04, AN 2002-211023 & JP 2001336053 A (DAIWABO CO LTD), 7 December 2001 (2001-12-07) abstract -- --------	1-19

INTERNATIONAL SEARCH REPORT
Information on patent family members

30/12/02

International application No.
PCT/FI 02/00995

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WO 0236339 A2	10/05/02	AU 2706502 A	15/05/02
		US 2002155772 A	24/10/02
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US 6028018 A	22/02/00	AU 722685 B	10/08/00
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		CN 1097117 B	25/12/02
		CN 1226294 A	18/08/99
		EP 0914509 A	12/05/99
		IL 127473 D	00/00/00
		JP 2000514883 T	07/11/00
		WO 9803713 A	29/01/98

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